



*Fluids and Combustion Facility*  
*Preliminary Design Review*

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# **LMM Mini-Facility Overview**

Edward Hovenac, FDC-LMM Project Manager  
February 12, 2001



# ***Fluids and Combustion Facility Preliminary Design Review***



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## **LMM Core Capabilities**

- LMM PI Projects
- LMM Layout Within FIR
- LMM Sub-Assemblies
- Data Handling and Storage
- Thermal Control
- Launch Considerations
- Summary



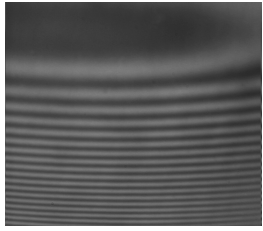
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### **Light Microscopy Module (LMM) Overview**

#### **Four Experiments – One Project**



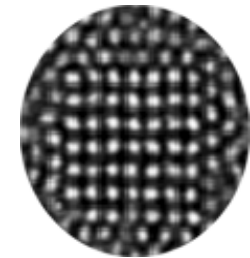
Constrained Vapor  
Bubble Film Thickness

**CVB: Prof. Peter C. Wayner, Jr., Rensselaer Polytechnic Institute**

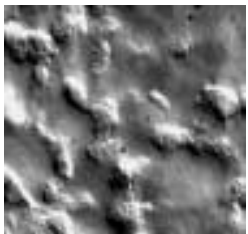
**Objective:** To determine the overall stability, the fluid flow characteristics, the average heat transfer coefficient in the evaporator, and heat conductance of the constrained vapor bubble, under microgravity conditions, as a function of vapor volume and heat flow rate.

**PHaSE-2: Prof. Paul M. Chaikin, Princeton University**

**Objective:** Perform investigations of hard sphere colloid growth, structure, dynamics, rheology, and phase diagram. Observe how hard sphere colloids respond to applied fields which force them into non-equilibrium conditions.



Laser Tweezers Pattern  
w/ Colloidal Particles



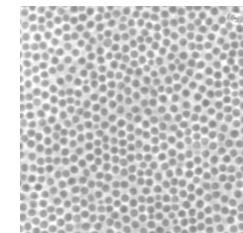
Colloidal Gel

**PCS-2: Prof. David A. Weitz, Harvard University**

**Objective:** To carry out further investigation of critical fundamental problems in colloid science and to fully develop the evolving field of “colloid engineering”, to create materials with novel properties using colloidal particles as precursors.

**LΦCA: Prof. Arjun G. Yodh, University of Pennsylvania**

**Objective:** To create photonic band-gap colloidal surface crystalline materials from high and low density particles in low volume fraction binary particle suspensions using entropy driven crystallization.



Colloidal Patterning on  
Etched Substrates



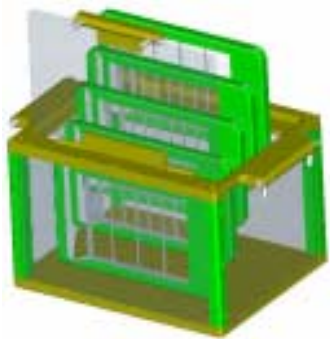
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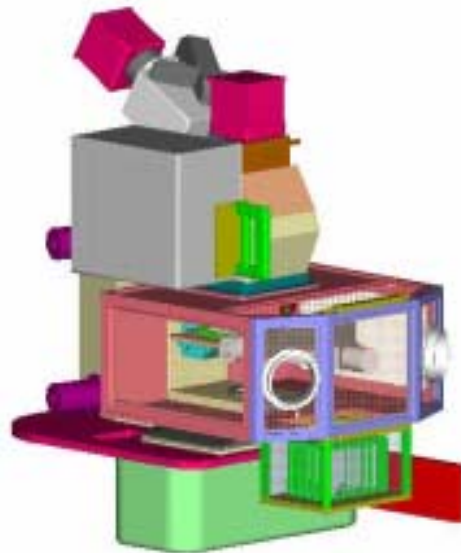
### Integrated LMM/FIR Concept

The FCF FIR includes support subsystems and laboratory style diagnostics common to the specific researchers and supplements the laboratory with unique science hardware developed for each Principal Investigator (PI). The PI unique hardware customizes the FCF FIR facility in a unique laboratory configuration to perform fluid physics research effectively.



#### PI Specific Hardware

- PI Sample Cell with universal Sample Tray
- Specific Diagnostics
- Specific Imaging
- Fluid Containment



#### Light Microscopy Module

- Test Specific Module
- Infrastructure that uniquely meets the needs of PI fluid physics experiments
- Unique Diagnostics
- Specialized Imaging
- Fluid Containment



#### FCF Fluids Integrate Rack

- Power Supply
- Avionics/Control
- Common Illumination
- PI Integration Optics Bench
- Imaging and Frame Capture
- Fluid Diagnostics
- Environmental Control
- Data Processing
- Frangibles and Laser Light Containment

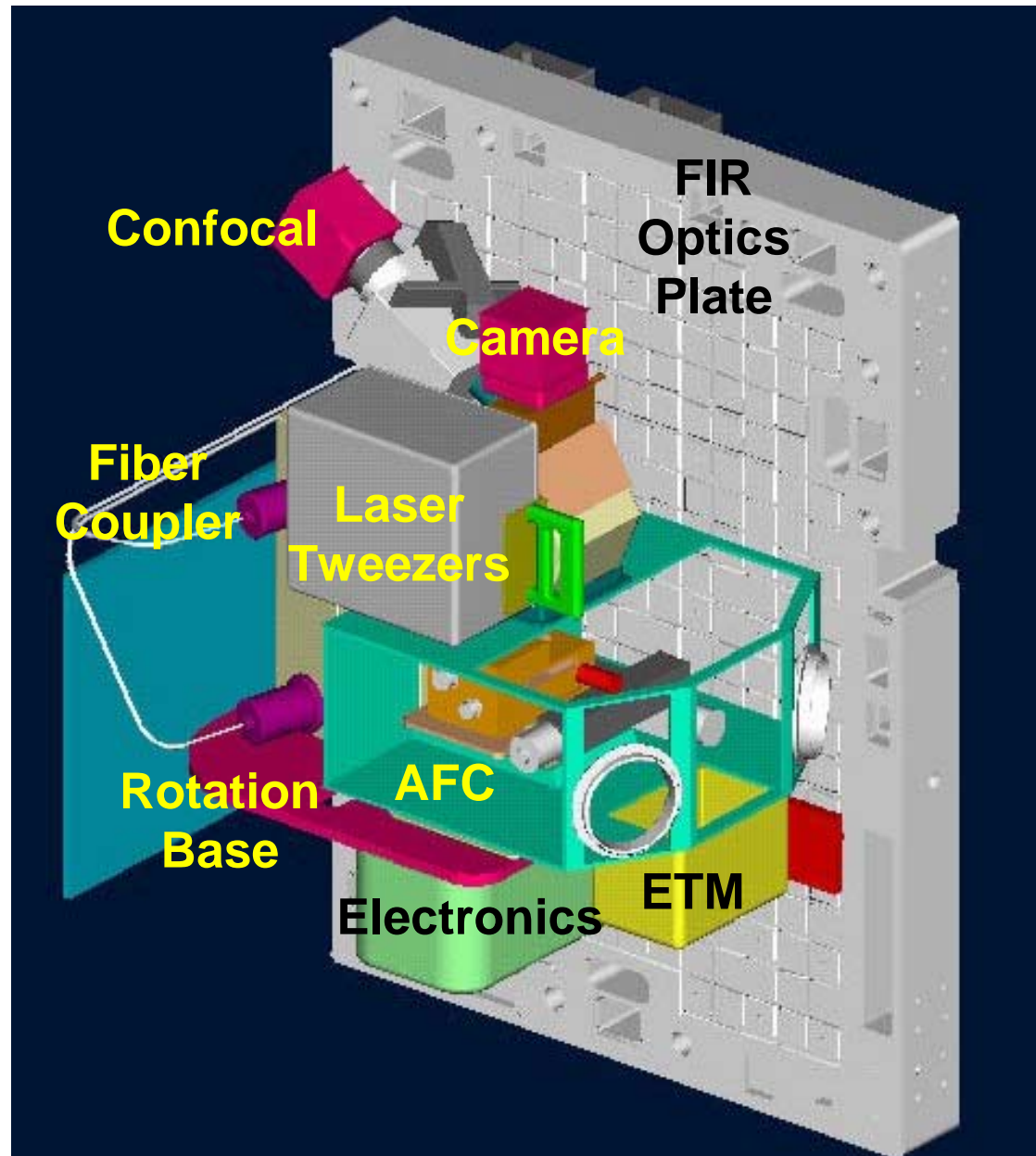


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### LMM Shown in Operating Position



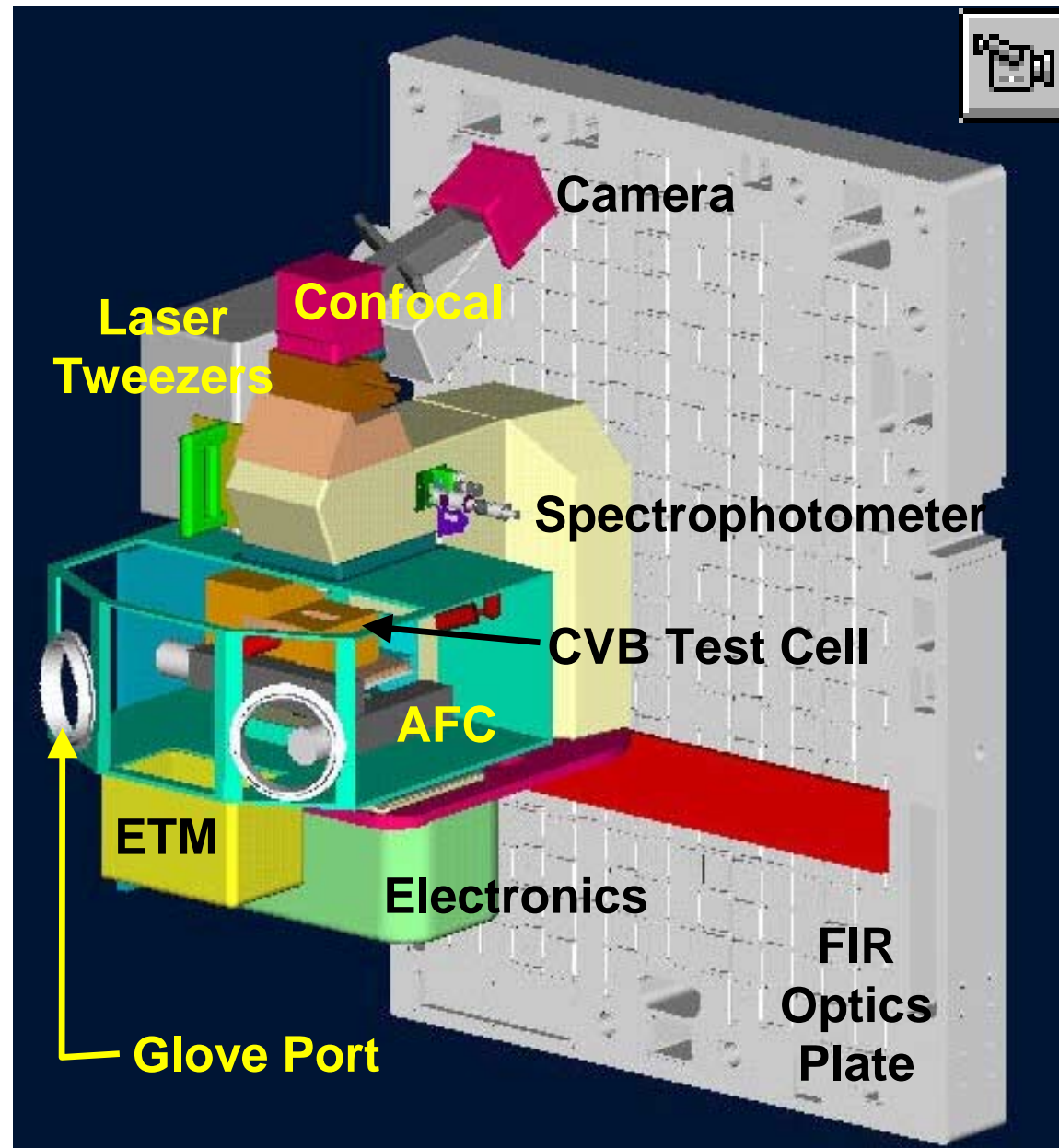


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### **LMM Shown in Open Position**



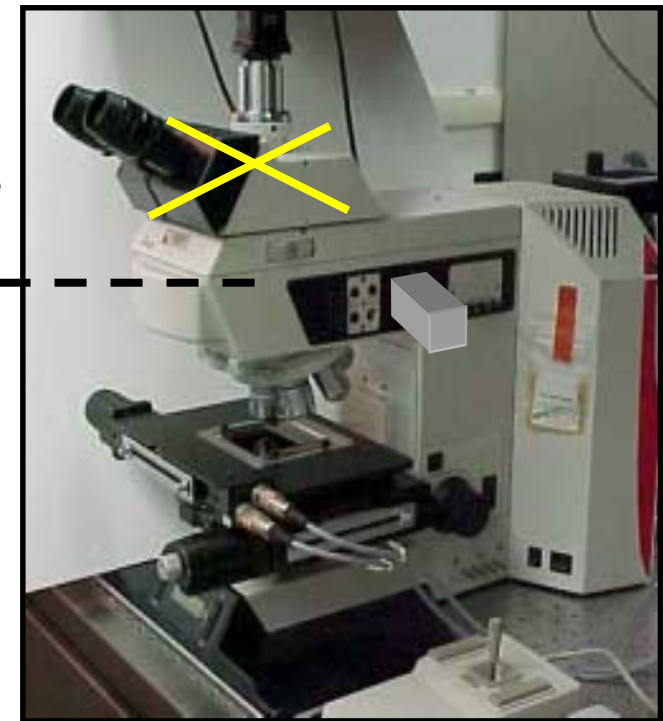
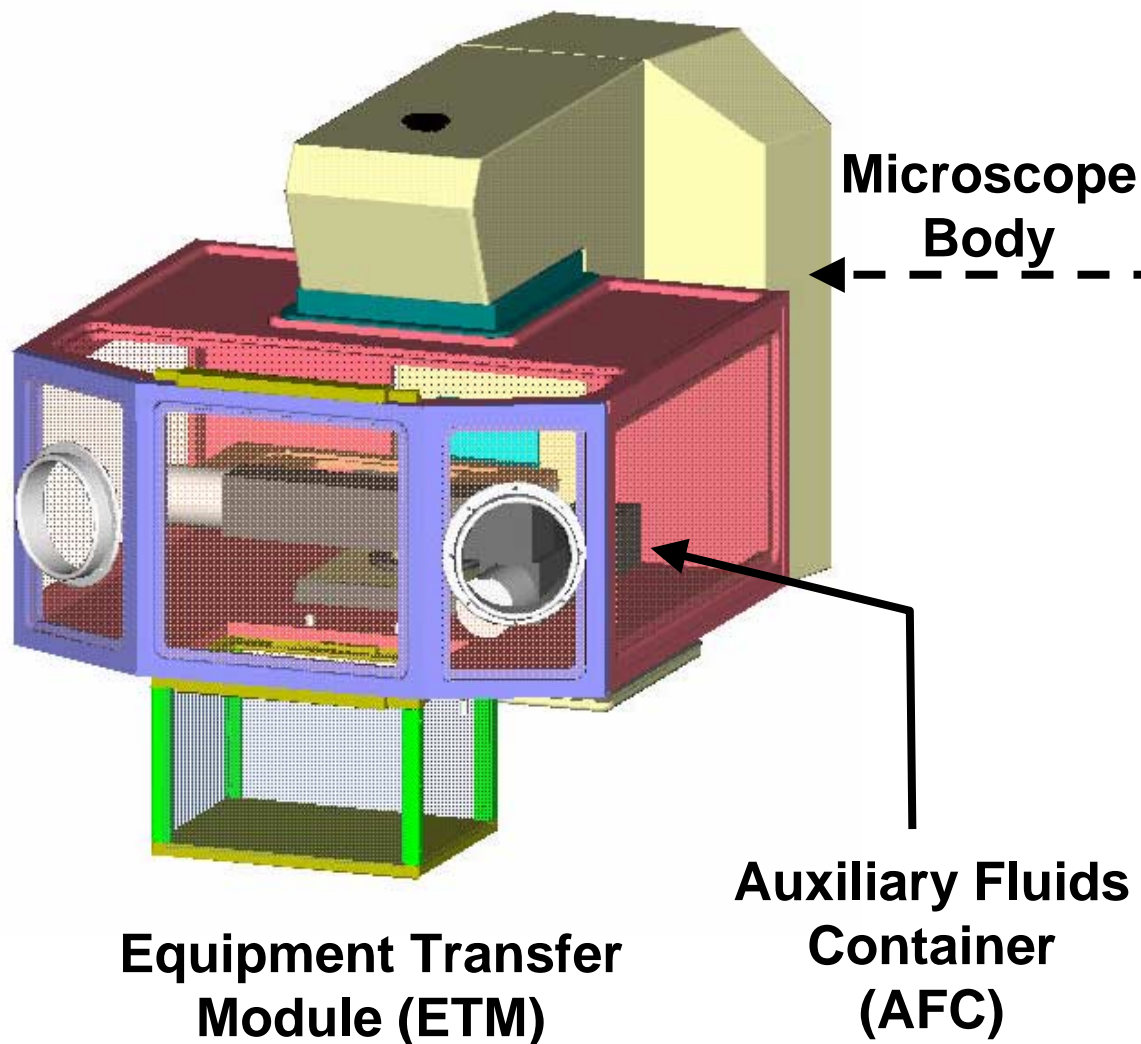


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### The Primary Structural Components of LMM



**LMM is Flying a  
Commercial  
Microscope**

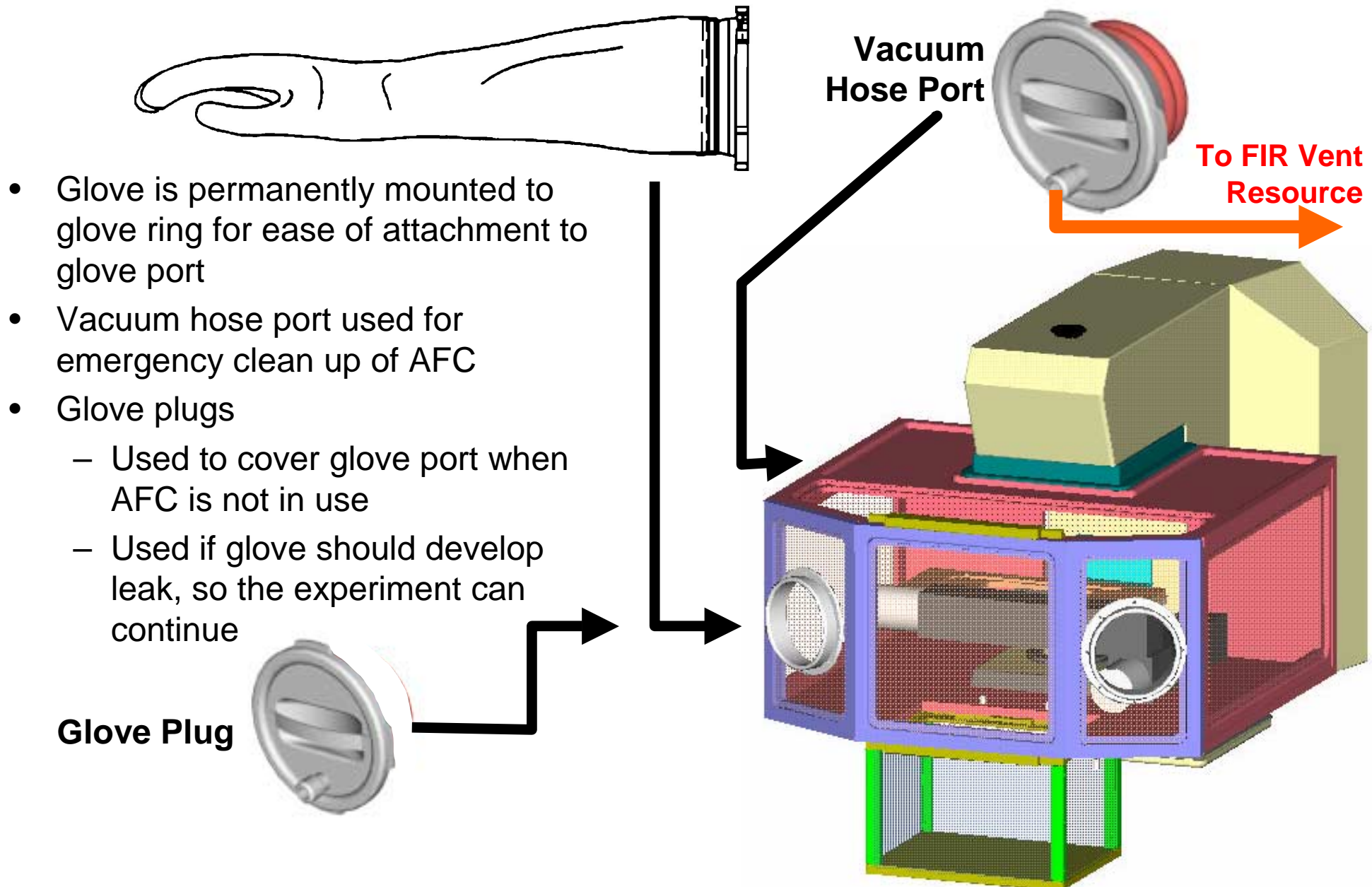


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### Glove, Plug and Vacuum Port Concepts



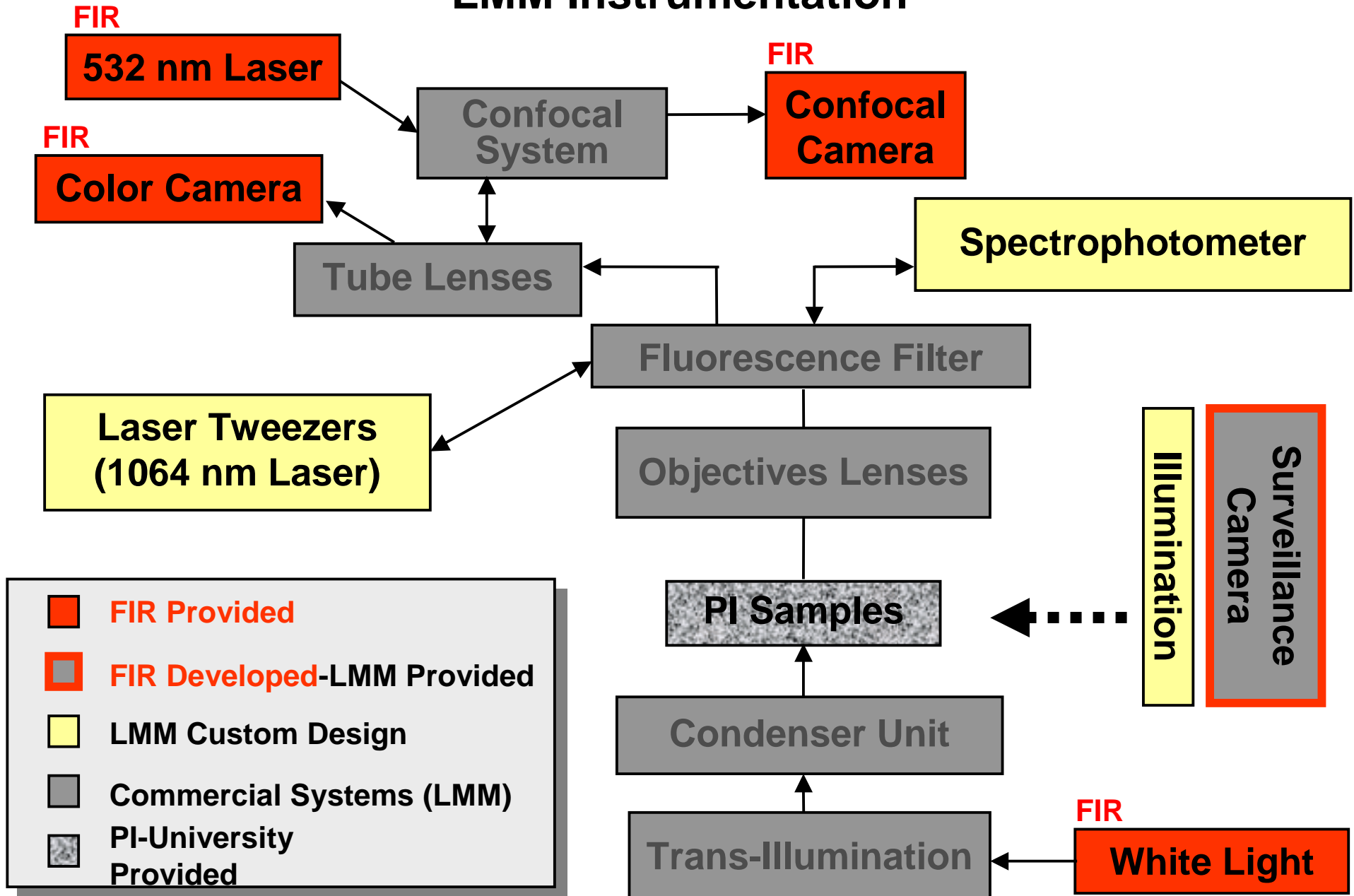


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### LMM Instrumentation



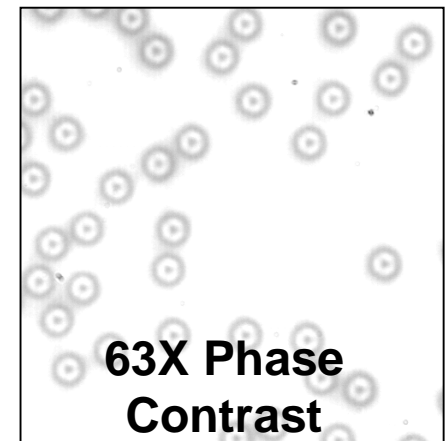
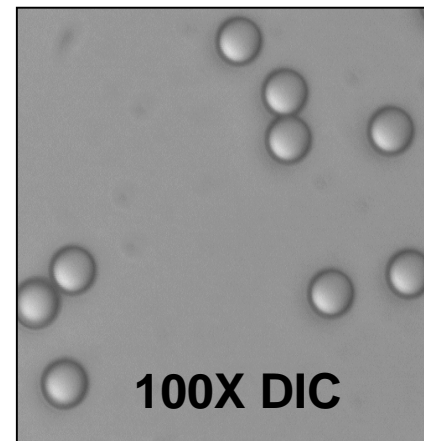
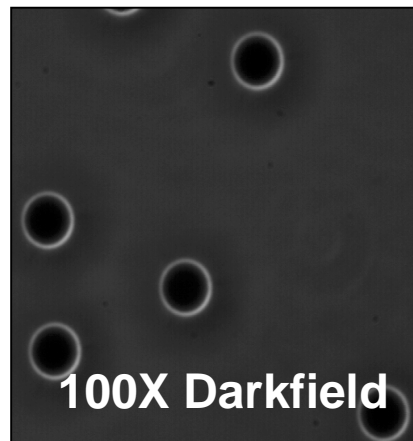
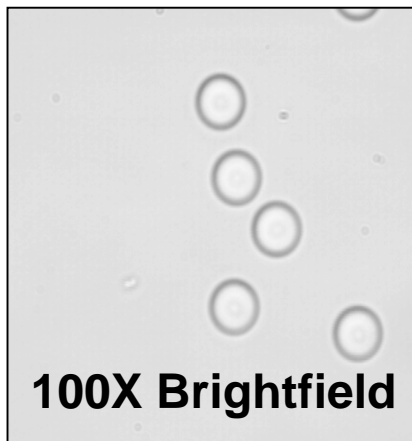


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### **Sample Images from the LMM Microscope Using Standard Microscope Functions**



#### **Experimental Setup**

Particle diameter: 5 micrometers  
Polystyrene spheres  
LMM microscope images

Science Requirement: Visualize samples using standard microscopy techniques.

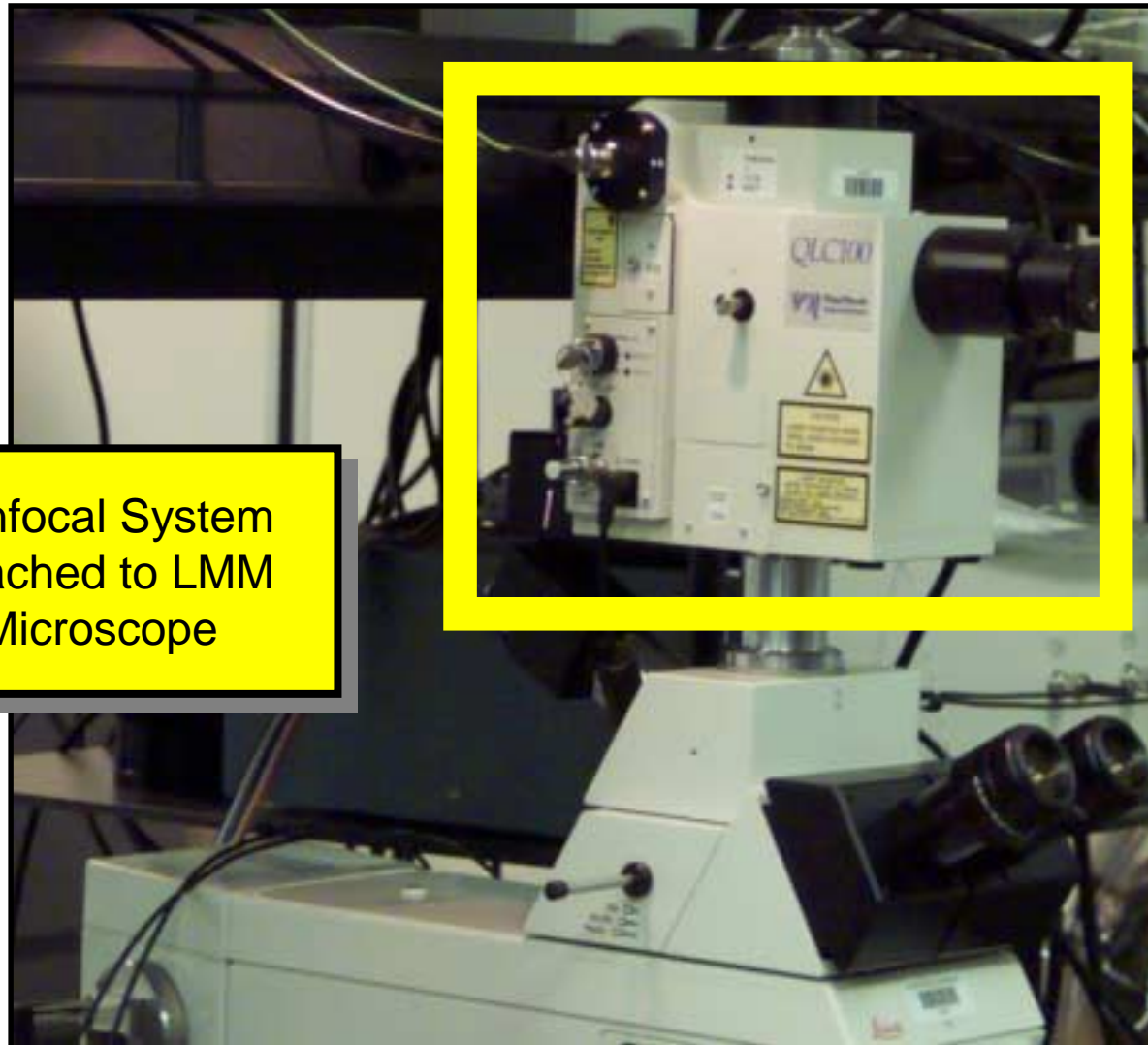


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### **Confocal Microscopy**



Confocal System  
Attached to LMM  
Microscope

Science Requirement: Provide optical sectioning.



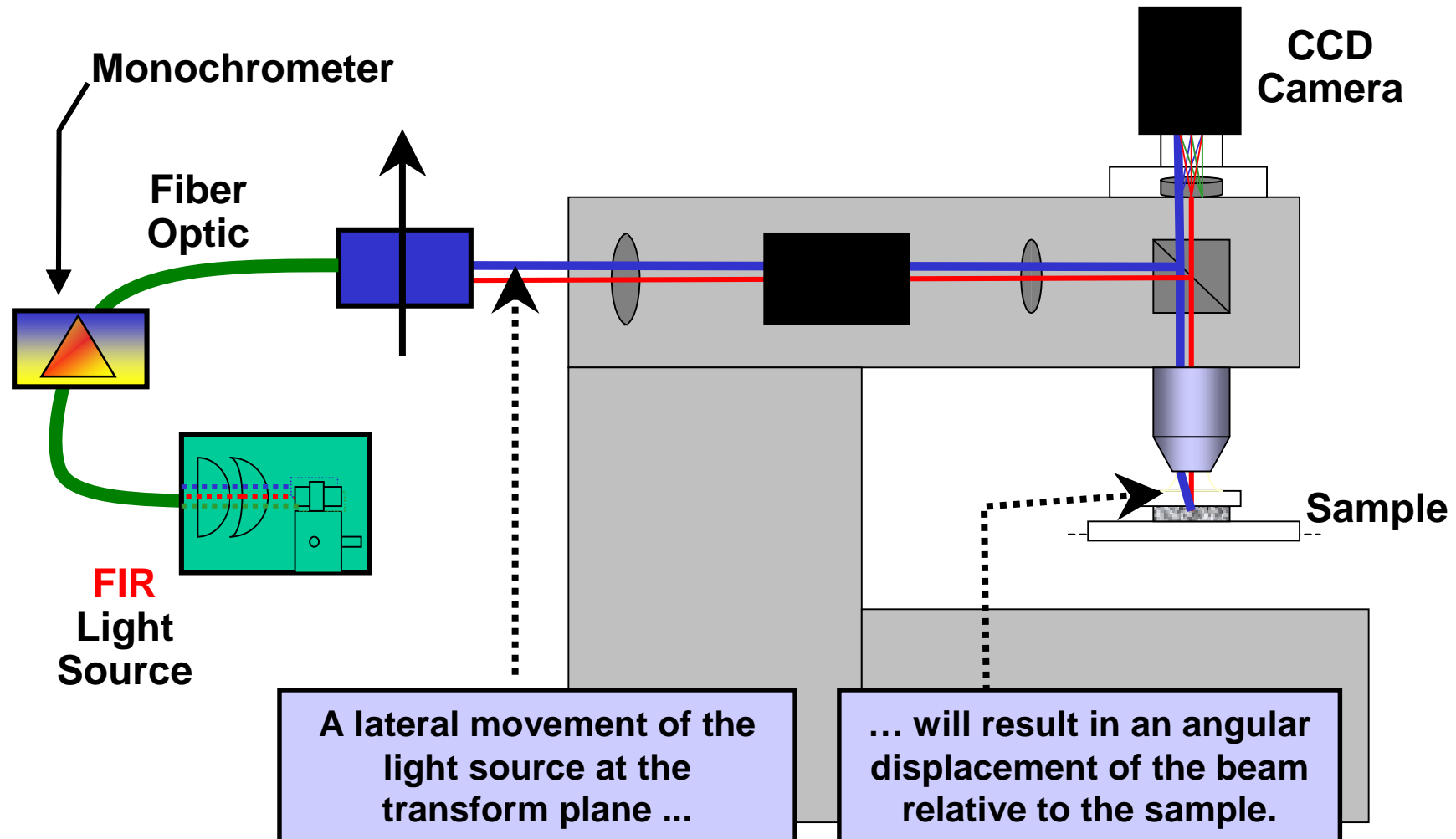
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### Implementing Spectrophotometer Requirements

#### Vary Illumination Angle Relative to Sample





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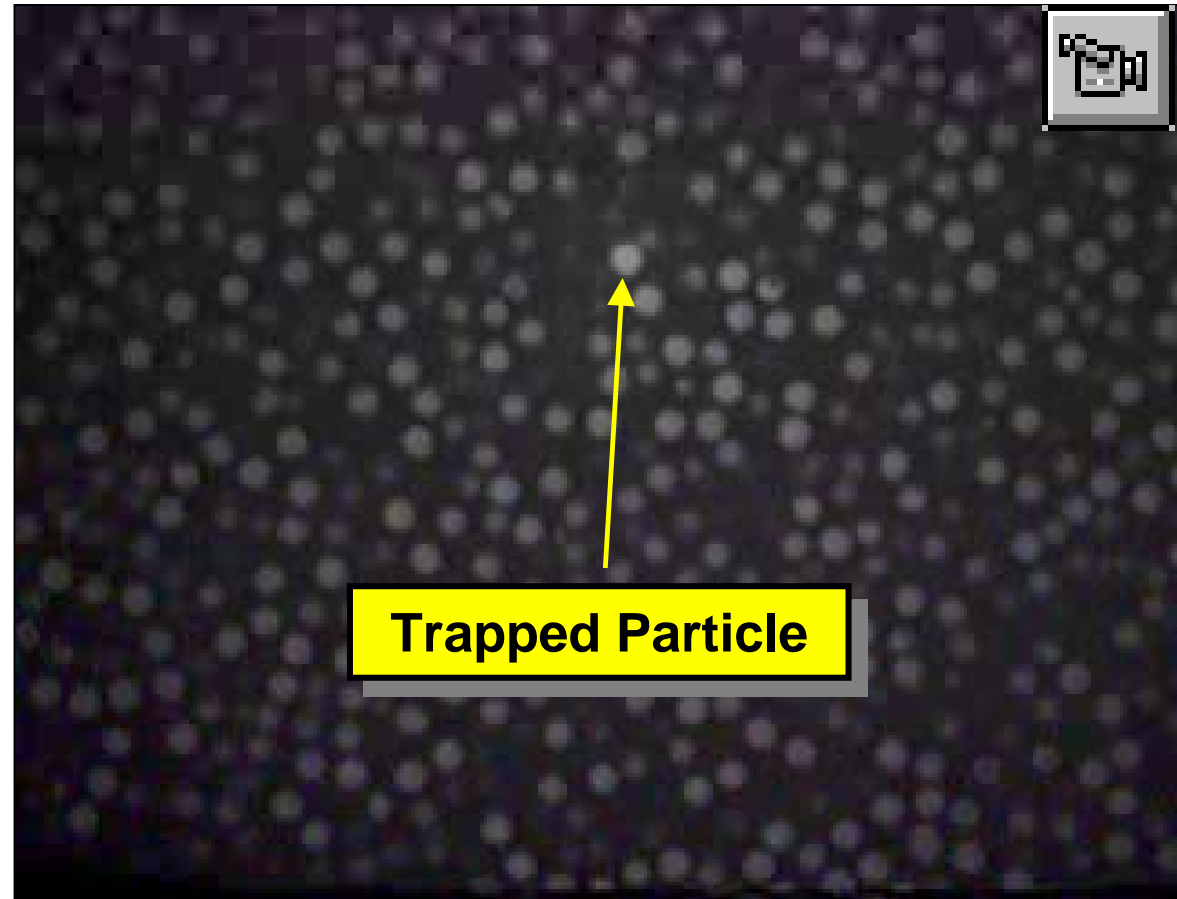
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### **Sample Footage Of LMM Laser Tweezers In Action**

#### **Experimental Setup**

- Rhodamine dyed PMMA in decalin and tetralin
- Particle diameter: 2 - 3  $\mu\text{m}$ .
- Stable trap in 3-dimensions.
- Trap strength sufficient to drag particle through colloid.
- Optical configuration: 100x oil immersion lens, confocal imaging.



Science Requirement: Implement tweezing simultaneous with confocal imaging.



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### **Data Handling and Storage**

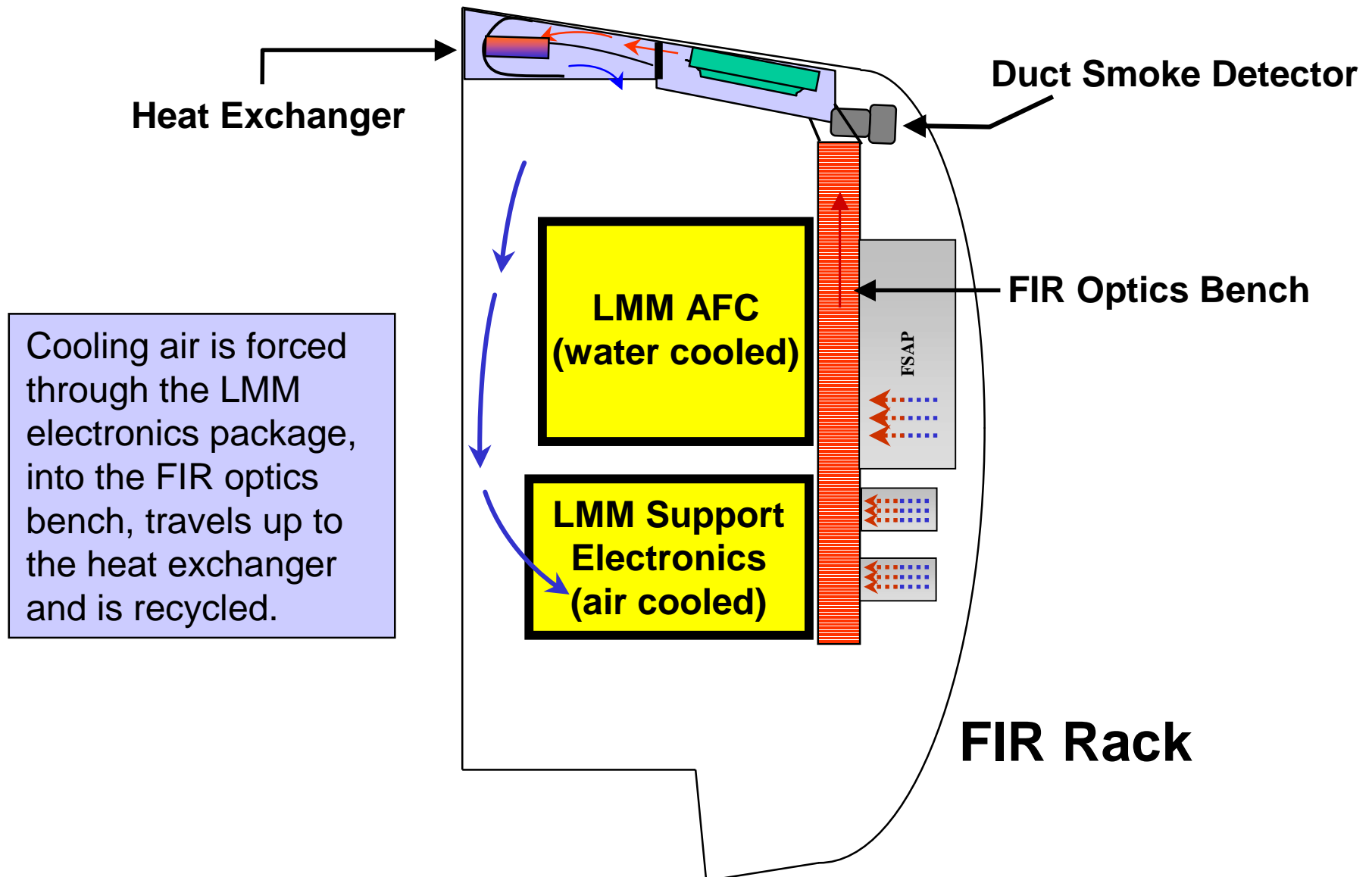
- All data will be stored on FIR provided devices.
- FIR storage capacity:
  - FSAP: 2 - 18 GB non-removable disks.
  - IPSU: 2 - 18GB non-removable disks (3.5" form factor)
  - IOP: 2 - 73GB removable disks (3.5" form factor)
- Data will be transferred from non-removable disk storage to removable disks.
- Large quantities of data will be generated by the confocal system. However, huge compression ratios can be realized by reducing image cubes to x,y,z particle centroid locations (CPU intensive activity).
- Surveillance camera data will be down linked as close to real time as possible.
- During periods of LOS, surveillance camera images will be compressed and stored for possible down link during AOS. Due to the large volume of the surveillance camera data, it will not be permanently stored. When the data becomes obsolete, it will be overwritten by new surveillance camera data.



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## FIR/LMM Thermal Design Concept





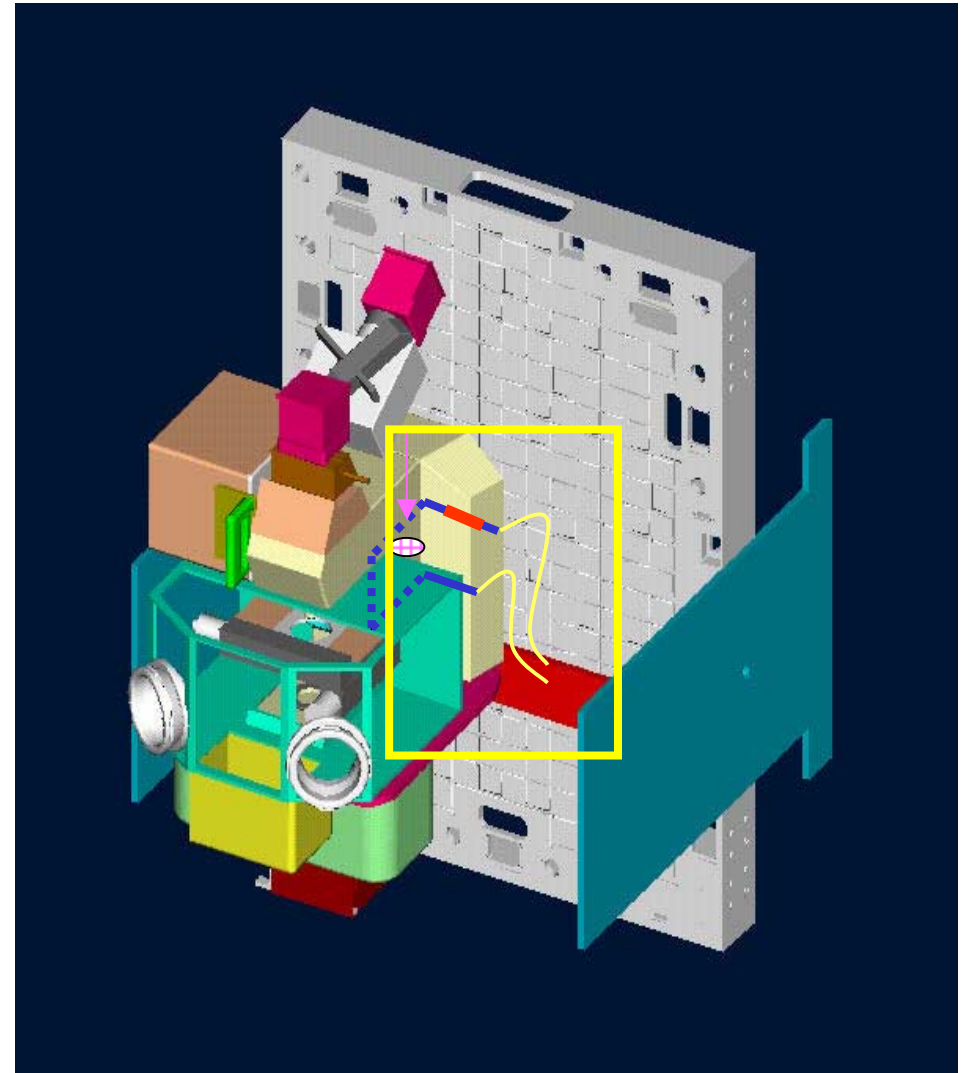
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### **Thermal Control of the AFC**

- Flexible tubing brings water for cooling into AFC.
- Internal fan distributes cool air throughout AFC.
- Flexible cooling hoses supply and return cooling water to FIR.
- Cooling tubes within AFC also provide cooling to CVB Test Module (not shown).
- AFC internal temperature monitored.



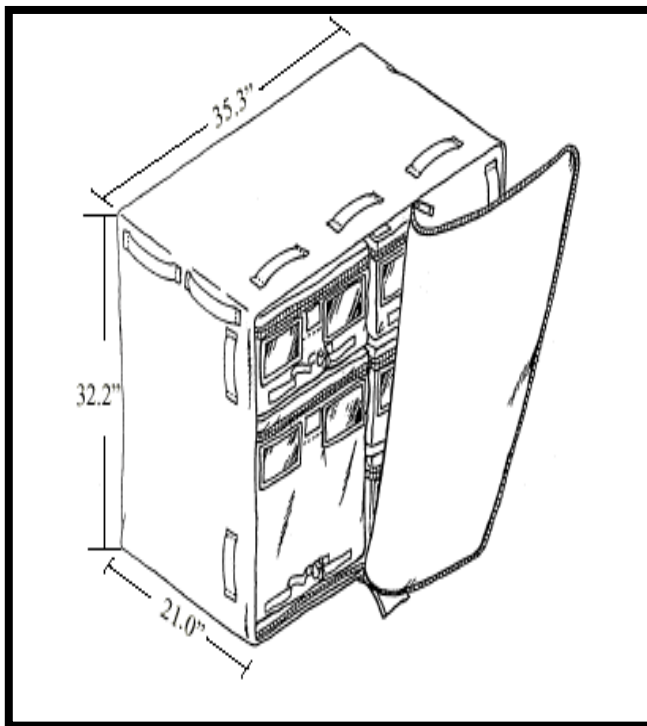


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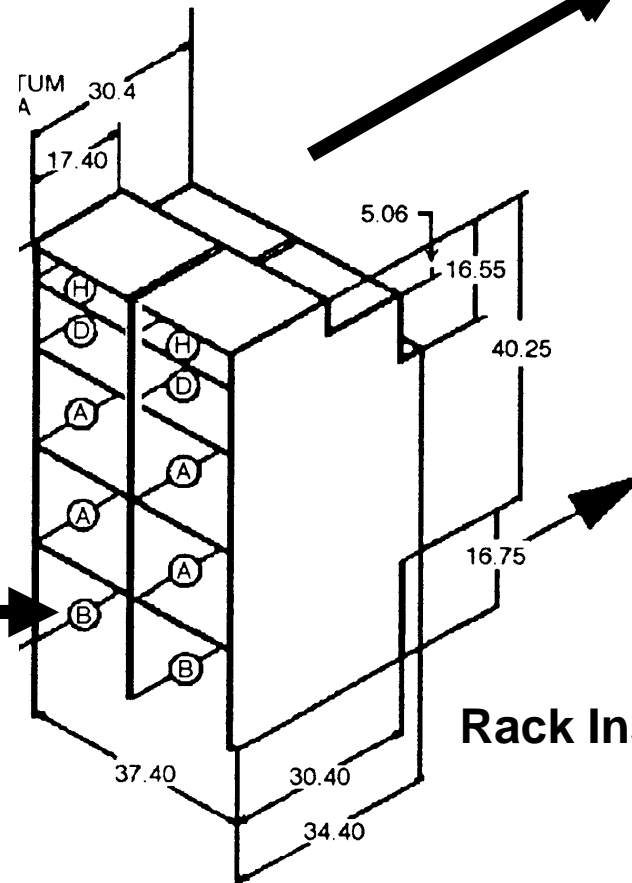
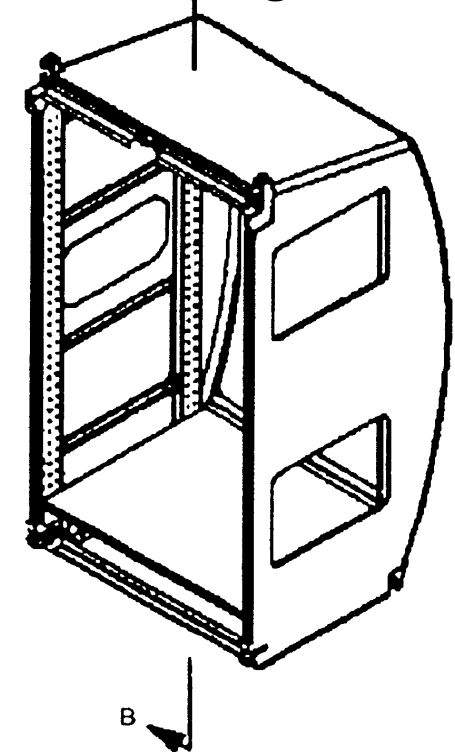
## LMM Launch Considerations

**LMM Hardware Packed  
in Soft Stowage Bags**



LMM components are modular and will be integrated into the FIR on-orbit.

**MPLM Stowage Rack**



**Rack Insert**



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## **Summary**

LMM engineers are working closely with FIR engineers to verify interfaces, test FIR-provided hardware and to provide an integrated system that meets the needs of the science community.